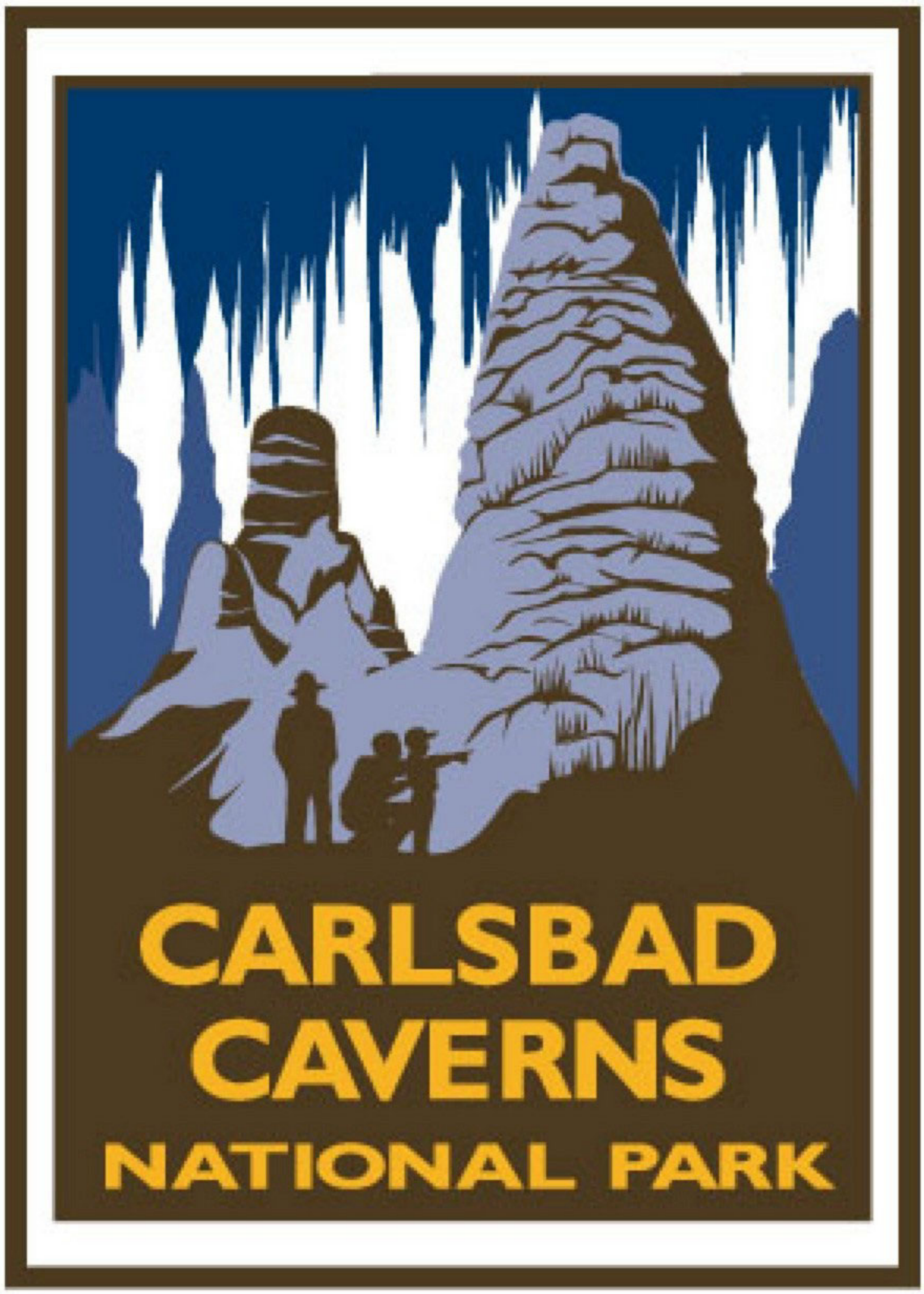
Caves, Canyons, Cactus & Critters

A curriculum and activity guide for Carlsbad Caverns National Park

Middle School Geology



Caves, Canyons, Cactus & Critters
Geology Curriculum

Wandering Continents

Carlsbad was, at one time, located near the equator. Fossils of tropical plants have been found in Antarctica. The same animals and rocks are found on different continents. These, and many other pieces of evidence, point to an earth that may not be as static as we would like to believe. Throughout the past century, scientists looking at these, as well as many other bits of information, have come to the conclusion that the continents are moving. Research has shown that the floor of the Atlantic Ocean is spreading in the middle. Seismology has found evidence of large, convective plumes in the mantle that move the broken lithospheric plates around like a conveyor belt.

Continents moving around on the surface of a planet are going to do some damage. Colliding continents result in mountains as they crumple up. The heat generated by the friction of their impact causes some of the rock making up the continents to melt. This molten rock rises to the surface, near the point of the collision, and creates a volcano. Continents pulling apart result in basins. These basins sink below sea level and are covered by water. Earthquakes are an obvious consequence of stresses in the lithospheric plates as well.

The activities of this unit are designed to supplement classroom studies of plate tectonics and their effect on the surface of the earth.

Apples, Eggs and Earth

What is the earth like inside?

Summary: Students will use apples and hard-boiled eggs to model the earth's internal structure.
Duration: One 50-minute class period
Setting: Classroom
Vocabulary: convection cell, crust, inner core, lithosphere, mantle, model, Mohorovicic Discontinuity, outer core, plasticity
Standards/Benchmarks Addressed: SC1-E1, SC2-E2, SC2-E3, SC4-E1, SC4-E5, SC6-E1, SC6-E8, SC12-E3

Objectives
Students will:

- describe the earth's internal layers.
- use apples or hard-boiled eggs to model the earth's internal layers.

Background

What is the earth like inside? Is it all magma? How do we know? Throughout history, there has been speculation on what was really in the center of our planet. Some speculated that the earth was a hollow sphere with an entire civilization living on the inside. In 1864, Jules Verne wrote *Journey to the Center of the Earth* in which the lost continent of Atlantis, dinosaurs, and a great deal of adventure were found at the center of the earth. It was only in the past century that we began to have any understanding of what was really in the center of our planet.

It is only with the development of the science of seismology that we have been able to peek at what lies beneath us. In 1909, a Yugoslav scientist Andrija Mohorovicic discovered that seismic waves changed speed somewhere between 32 and 64 kilometers beneath the earth's surface. The *Mohorovicic Discontinuity*, as it came to be called, marked the boundary between the earth's crust and the mantle. Subsequent studies have shown the earth's interior to be composed of four major layers: the crust, the mantle, the outer core, and the inner core. Recent studies have shown that even these layers can be subdivided and boundaries between them may not be as clearly defined as it was once thought.

The earth's dense center is called the *inner core*. It has a radius of approximately 1,300 kilometers and begins at a depth of around 5,150 kilometers. It is composed of nickel and iron. Temperatures in the inner core reach 5,000° C. This is well beyond the melting point of nickel and iron. However, the intense pressure at the center of the earth pushes the atoms of nickel and iron together so tightly that they remain solid.

Around the inner core is the liquid *outer core*. It begins at a depth of about 2900 kilometers and is around 2250 kilometers thick. The lower pressures in this layer allow the nickel and iron to melt. However, the temperatures are still high, ranging from around 2200^{o}C in the upper part to almost 5000^{o}C near the inner core.

The layer directly beneath the earth's crust is the *mantle*. It is composed mostly of the elements silicon, oxygen, iron, and magnesium. Even though it is solid, the high temperatures and pressure allow the solid rock to flow. This property is referred to as *plasticity.* Temperatures range from 2200^{o}C near the bottom to 870^{o}C near the top. Seismic research has indicated that the mantle contains great, slow moving convection *cells*. In these cells, the hotter, less dense mantle material rises toward the top while the cooler, denser material sinks toward the bottom.

The thin, outermost layer of the earth is called the *crust*. It consists mainly of the elements oxygen, silicon, magnesium, and aluminum. Iron, calcium, sodium, and potassium are also abundant. The thickness of the crust varies from 8 kilometers under the oceans to 70 kilometers under continents. The younger, denser areas of oceanic crust are composed primarily of basaltic rocks and are thinner. The older, less dense areas of continental crust are thicker and composed primarily of granitic rocks.

The earth's crust and the upper part of the mantle compose the *lithosphere.* The lithosphere is broken into large sections called lithospheric plates. There are seven major plates and several minor plates. Most plates contain both continental and oceanic crust. The movement of these plates is called continental drift.

Materials

- hard boiled eggs (one per group)
- apples (one per group)
- small sharp knives (one per group)
- paper for drawing observations
- crayons or colored pens
- basketball
- solid rubber ball

Procedure

Warm up: Ask the students, "What is a *model*?" Discuss the ways in which a model is built to a particular scale.

Hold up a basketball, a solid rubber ball, and an apple and ask the students, "Which of these provides the best model of what the earth is like inside?" List the reasons for their choice on the board or on an overhead.

Activity: This activity can be done in groups, or as a teacher-led demonstration.

1. Show the students a hard-boiled egg. Ask them to describe its parts to you. Discuss the fragile nature of the shell. Ask the students if they think the egg would be a good model of the earth.
2. Gently tap the egg on a hard surface, trying to make it crack into large "plates." Describe the earth's crust to the students and introduce the idea of lithospheric plates. While doing this, outline the plates with a marker. Have the students draw what they observe.
3. Using a sharp knife gently cut the egg lengthwise and show it to the students. Introduce the idea of the layers in the earth and describe each layer to the students. Be sure to point out that even though a single yolk represents the core, the earth actually has two

layers at its core. Ask the students to list good and bad points of using an egg to model the earth's interior.

4. Give each group an apple and a knife and have them do the following:
   a. Slice the apple, top to bottom, into as many pieces, or wedges, as the group has students.
   b. Have each student sketch his or her slice of apple on a piece of paper.
   c. On their sketch, have the students label each of the layers in the apple with the name of the layer in the earth it represents.
   d. For each layer, have students list its properties on the paper.
   e. On the paper, have students list good and bad points of using an apple to model the earth's interior.

Wrap Up: Allow students to eat their slice of the "earth."

Solicit suggestions from the students for other objects that could be used to model the earth. For each, briefly discuss its good and bad points.

Assessment
Have students:

- turn in papers with sketches and answers.
- list and describe each of the layers in the earth.
- tell what characteristics make a good model.

Extensions
Have students design and build their own model of the earth's interior using materials of their own choosing.

Resources
Coble, Charles, et al. 1993. *Prentice Hall Earth Science.* Englewood Cliffs, NJ: Prentice Hall.

Ford, Brent. 1996. *Project Earth Science: Geology.* Arlington, VA: National Science Teachers Association.

Come Visit Me in Tropical... Antarctica?

Why are tropical plant fossils found in Antarctica?

Summary: Students will use a map of the continents as they are today and attempt to work backward to reconstruct Pangea.
Duration: One 50-minute class period
Setting: Classroom
Vocabulary: continental drift, sea-floor spreading, plate tectonics
Standards/Benchmarks Addressed: SC1-E1, SC1-E2, SC2-E1, SC2-E2, SC4-E1, SC4-E5, SC5-E2, SC6-E1, SC6-E8, SC12-E3

Objectives
Students will:

- describe evidence for the theory of continental drift.
- explain the importance of continental drift in the formation of the Capitan Reef.

Background

Have you ever taken a really close look at a globe or a map of the earth and noticed that some of the continents look as if they would almost fit together like the pieces of a jigsaw puzzle? In the early 1900s, a scientist named Alfred Wegener did just that. In fact, he went so far as to propose that the continents were moving and had at one time been joined into a single large landmass. He named this landmass Pangea, meaning, "all land." Prior to his death in 1930, he lacked the evidence to convince many of his theory. However, since that time researchers have enough proof that Wegener's theory is now widely accepted as accurate.

Among the pieces of evidence supporting the theory of continental drift are the puzzle-like fit of the continents, fossil clues, climate clues, and rock clues. Fossils of the same animal, a *Mesosaurus,* have been found in both South America and Africa. The fossil fern, *Glossopteris,* has been found in Africa, Australia, India, South America, and in Antarctica. Other fossils have also been found on continents separated by hundreds or thousands of miles of ocean water. Several hypotheses, including continental drift, have been proposed to explain this.

Fossils of plants from much warmer climates have been found in Antarctica and on Spitzbergen, an island in the Arctic Ocean. Additionally, evidence of glaciation has been found in warm regions of South America, Africa, India and Australia. Again, several hypotheses have been proposed to explain this, one of which is continental drift.

Similar rock types and structures have been found in Africa and South America. If you were to fit the two together like the pieces of a puzzle, these layers would match. Mountains similar to the Appalachian Mountains of the eastern United States have been found in Greenland and western Europe. Again, if you were to fit the continents together like the pieces of a puzzle, these mountains would match like one long chain. Several hypotheses could be proposed, including continental drift.

Since the early 1960s, additional evidence has come from research regarding the spreading of the Atlantic Ocean floor and actual measurements of continental movement. Princeton University scientist Harry Hess first suggested *sea-floor spreading*. However, it was not until scientists aboard the research ship *Glomar Challenger* gathered information from the rocks on the ocean floor that sea-floor spreading was confirmed. Actual measurements have now been made that indicate the exact direction, and speed, at which the continents are moving.

With confirmation of *continental drift*, a new theory called *plate tectonics* was proposed. It states that the crust of the earth is broken into plates that move around on the mantle. Included in the theory are descriptions of the plates, the forces in the asthenosphere, part of the upper mantle, that drive them, and what happens along the plate boundaries.

Materials

- Copies of continent maps (from this activity, or others you have copied from another source, including the continental shelf if possible) one per student
- photos or pictures from magazines cut in a jigsaw pattern
- scissors
- paste (glue sticks are best)
- paper

Procedure

Warm up: Give each group of three or four students one of the photos or pictures that has been cut up and tell them to reform the image. After they are done ask what clues they used to help them.

Have the students look at a map that clearly shows all of the continents. Ask if they think the continents look a little like a poorly constructed jigsaw puzzle.

Activity

1. Give the students copies of the continents sheet (or the continent maps you are providing).
2. Instruct the students to cut out each continent and arrange them on a piece of paper as they are found today.
3. Tell the students that they are to do their best to fit the continents together like a jigsaw puzzle. However, they cannot pick up a continent, they must slide them. They are not allowed to "leapfrog" over other continents. Suggest that they may want to close the Atlantic Ocean first, since South America and Africa obviously fit.
4. Once they have the continents arranged as they believe that they may have been at one time, have them glue them onto the piece of paper.

Wrap Up: As a class, discuss any difficulties the students had fitting the continents together. Ask the students, "If the continents were really together like this at one time, what evidence should I find to support it?" Discuss all answers.

Lead a class discussion of Alfred Wegener's theory of continental drift and the evidence that has been found since that time to support it.

Assessment

Have students:

- submit their "continental" jigsaw puzzles.

- describe evidence supporting the theory of continental drift.

Extensions
Have students conduct further studies regarding what happens at plate boundaries. Focus on divergent, convergent, and transform fault boundaries. Describe various surface features seen on the earth that serve as evidence of these boundaries.

Resources
Feather, Ralph, et al. 1999. *Glencoe Earth Science.* Westerville, OH: Glencoe/McGraw-Hill.

Ford, Brent. 1996. *Project Earth Science: Geology.* Arlington, VA: National Science Teachers Association.

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Worksheet